DEPARTMENT OF THE INTERIOR.

PRELIMINARY REPORT

OF THE

FIELD WORK

OF THE

U. S. GEOLOGICAL AND GEOGRAPHICAL SURVEY

OF

THE TERRITORIES

FOR THE

SEASON OF 1877.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1877.

DEPARTMENT OF THE INTERIOR.

PRELIMINARY REPORT

OF THE

FIELD WORK

OF THE

U. S. GEOLOGICAL AND GEOGRAPHICAL SURVEY

OF

THE TERRITORIES

FOR THE

SEASON OF 1877.

WASHINGTON:
GOVERNMENT PRINTING OFFICE
1877.

PRELIMINARY REPORT

OF THE

FIELD-WORK OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES,

UNDER THE DIRECTION OF PROF. F. V. HAYDEN,

FOR THE SEASON OF 1877.

OFFICE OF THE UNITED STATES GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES,
Washington, D. C., December 1, 1877.

SIR: I have the honor to submit the following preliminary report on the operations in the field of the Survey under my charge during the season of 1877.

On the completion of the survey of Colorado last year, it was determined that the work of the United States Geological and Geographical Survey of the Territories under my direction should continue northward into Wyoming and Idaho. The belt of country including the Pacific Railroad having been explored and mapped in detail by the Survey of the Fortieth Parallel, under Clarence King, esq., it was deemed best to commence at the northern line of that work, and continue northward and westward, taking for the season of 1877 the country from Fort Steele, Wyoming Territory, to Ogden, Utah, or, more exactly, from longitude 107° to 112°, and northward to the Yellowstone Park.

The primary-triangulation party, in charge of Mr. A. D. Wilson, Chief Topographer of the Survey, took the field from Rawlins Springs, Wyo. Near this point a base line was measured with great accuracy, from which a net-work of triangles was extended over the country to the north and west, locating, at intervals of from twenty to thirty miles, some prominent peaks, upon which stone monuments were built, in order that the topographers could recognize the points thus fixed for them. Upon these points was based the system of secondary triangulation.

From the base at Rawlins, the work was carried northward to the Sweetwater Mountains, and thence to the Wind River Range. Upon some of the more prominent peaks of the latter range, such as Frémont's Peak, the stations were made with much difficulty, owing to the great masses of snow found there during the month of June, when the party was working. From this range the work was carried across the Green River Basin to the mountains on the west and north, where several stations were made. The work was resumed to the west as far as Fort Hall, Idaho, and thence south to the vicinity of Bear Lake, where another base, or base of verification, was measured; thence south as far as Ogden and Evanston, connecting with the triangulation of the Fortieth Parallel Survey at these points. From Evanston the party marched eastward, making some stations north of the railroad, thus bringing the work back to the point of beginning, Rawlins Springs, where the party was disbanded for the season. The system of triangulation employed

during the past season was essentially the same as that carried over Colorado.

The triangulation is all-important, as the topographical work depends entirely upon it, and the geologist can do but little without an accurate map. Thus the topographical as well as the geological maps are dependent upon a good system of primary triangulation.

In addition to the primary-triangulation party already referred to, there were three fully equipped divisions for topographical and geological work, and another, under the direction of Dr. C. A. White, for critical palæontological work.

The area assigned to the Green River division, under the direction of Mr. Henry Gannett, was rectangle No. 56, which is limited on the east and west by the meridians of 109° 30′ and 112° and on the north and south by the parallels of 43° and 41° 45′. This is an area of about 11,000 square miles, lying in parts of Wyoming, Utah, and Idaho. The party took the field at Green River City, Wyo., on June 1. They first surveyed the drainage of Green River Basin. For this purpose they traveled up the Big Sandy, a large eastern branch of the Green, to the foot of the Wind River Mountains; thence crossing the head of the basin, fording the large and rapidly rising streams which make up the New Fork of the Green, they reached the main Green, and traveled down its western bank, going in to Granger, Wyo., on the Union Pacific Railroad, for supplies on June 23.

The Green River Basin is a broad, flat, almost unbroken expanse, covered mainly with sage, among which considerable grass is scattered. Its greatest width in this district is about 50 miles, and its length reaches nearly a hundred. Its area within the district is not far from 3,000 square miles.

The river-bottoms of the Green and its branches, excepting the Big Sandy, are everywhere broad and beautiful, well covered with grasses, and shaded by magnificent groves of cottonwood. For agricultural purposes these bottom-lands are very valuable, while the limitless expanse of bunch-land would afford grazing to enormous herds of cattle. The Big Sandy is in low cañon through most of its course.

Leaving Granger, the party next surveyed the broken, hilly country lying between the basin and the upper course of Bear River, north of Harris's Fork. Following this belt northward, these hills develop into mountains of considerable importance about those large branches of the Snake known as John Day's and Salt Rivers. The party surveyed this belt northward to the north line, whence, turning westward, they mapped the basin of the Blackfoot and the valleys of the Portneuf; thence going in to Fort Hall, early in August, for further supplies of provisions. Taking up this section of the district in the order in which it was worked, it will be noted that the valley of Harris's Fork is fine agricultural land; that the hills about its head, separating it from the Bear, are rounded and grass-covered, affording a magnificent stock-range. As the hills increase in size and assume the dignity of mountains, the grass gives place to heavy pine and spruce timber of fine quality. John Day's River flows in a cañon valley, heavily timbered. The valley of Salt River is nearly ten miles in width and of the finest quality of land. West of this valley are high, broken hills, separating Salt River from the Blackfoot. The latter stream pursues a devious course in a great plain of basalt, diversified by buttes and extinct craters. Along the river are fine meadows, alternating with large swamps. The whole basin is covered with the best of grass.

West of this basin the Blackfoot is separated from the Portneuf, here flowing south, by a range of low, grass-covered hills. The valley of the Upper Portneuf is at least eight miles broad, and is valuable for agriculture or grazing. West of it is a high range of mountains, through which, lower down, the Portneuf cuts its way into another broad valley, in which it flows to the north. This valley is floored with basalt, and is almost valueless.

From Fort Hall the party proceeded to survey the country drained by the Bear and its tributaries, proceeding generally from the east westward. The country is a succession of parallel valleys, separated by ranges of bare, grass-covered hills or timbered mountains. The most eastern of these valleys is on the upper waters of the Bear. It is nearly ten miles wide, of good soil, and easily irrigated. The only drawback to agricultural pursuits is the elevation, 6,000 to 6,500 feet, which, in this latitude, indicates severe winters.

Next westward is Bear Lake Valley. Here the cultivable area is at the head and foot of the lake, besides a narrow strip on its west border. Below the lake, the valley extends on to the northward for many miles down the Bear, and is very broad and fertile. The elevation of this valley is 5,500 to 6,000 feet.

Further westward we encounter the Bear River Range, a broad belt of mountains reaching nearly to 10,000 feet in height, and heavily timbered. Beyond is Cache Valley, one of the finest areas of farming-land west of the Missouri. The elevation is 4,500 to 5,000 feet. Besides grain, nearly all garden-vegetables and many fruits are raised in this valley.

A broken range of mountains separates this valley from that of the Malade. The latter has about the same elevation as Cache Valley, and is almost equally fine. Beyond it is a range of grass-covered hills, separating it from Blue Creek Valley.

The valleys of the Bear are peopled mainly by Mormons; very few Gentiles indeed are to be found there. Mormon settlements, of greater or less extent, are to be found all along the Bear, from its mouth nearly to Randolph. Malade Valley is but sparsely settled as yet. Cache Valley contains several good-sized towns; the eastern part of the valley is quite closely settled. The valley of Bear Lake contains several good-sized towns, but above that settlements are scarce.

The party left the field at Ogden, Utah, on September 30, having been in the field just four months. The area surveyed was between 12,000 and 13,000 square miles; 347 stations and locations were made; 53 of the stations, being important ones, were marked with stone monuments for future reference.

The geological work of Dr. A. C. Peale in the Green River district connected directly with the eastern edge of the Sweetwater district.

With the exception of a small area of granite along the southwestern side of the Wind River Mountains, and some basaltic flows in the northwestern portion of the district, the rocks are sedimentary, including the rocks from the Carboniferous to very late Tertiary age.

The first month of the season was occupied mainly with the survey of the Green River Basin. Leaving Green River City, the river was followed to the mouth of the Big Sandy, a shallow, muddy stream, rising in the southwestern slopes of the Wind River Mountains. Both on Green River and the Big Sandy the prevailing formation is the Green River Tertiary group, consisting of clays, marls, and calcareous sandstones, forming bluffs on the rivers. These strata continue uninterruptedly

westward, inclining eastward from the hills west of Green River. Toward the southern part of the district remains of the Bridger clays are seen, forming buttes on the Green River beds. They are the outlines of the extensive Bridger areas that extend southward. On the southwest slopes of the Wind River Mountains there are abundant evidences of comparatively recent glacial action.

The next area taken up was that lying between Green River and the Bear, with a strip along the northern edge of the district, reaching westward beyond Fort Hall.

The mountains west of Green River are composed mainly of Carboniferous limestones. Toward the north they form two beautiful ranges on John Day's River and Salt River, separated by a valley in which rocks of Jurassic and Cretaceous age outcrop. Between the mountains and the Green River Basin is a range of hills of Jurassic and Cretaceous age. On the east of these is the Wasatch group of Tertiary, resting unconformably on the Jurassic hills. Farther north the Wasatch beds cover the Jurassic and Lower Cretaceous strata, extending partly over the Laramie Cretaceous, with which it is unconformable. Carboniferous fossils were obtained from limestone bowlders in a conglomerate at the base of the Wasatch These were derived, without doubt, from the Carboniferous mountains to the westward, which formed the shore-line of the ancient lakes in which these beds were deposited. An arm of this lake extended up Harris's Fork of Green River. The Green River and Wasatch beds here are horizontal, the former containing abundant remains of insects and fish. Good collections were obtained at several localities.

The region of the Blackfoot River, in the northern portion of the district, is covered in the lowest portions with flows of basalt. These had their origin between the Blackfoot, Bear, and Portneuf Rivers. A number of the craters still remain. One of these, south of the Blackfoot, is very distinct, rising 200 feet above the general level. It is about 130 yards in diameter, and has a circular depression on the summit. The pouring out of this basalt must have occurred either during or immediately prior to our present period, as there has been little if any change in the surface since the eruption.

The Blackfoot, Portneuf, and Bear all have the basalt in their valleys. On the Portneuf it extends almost to the Snake River plain, showing as a narrow belt. Its surface slopes, but not so much as the present bed of the stream. In some places the volcanic rock appears to have pushed the river to the western side of the valley. The lower valley of the Portneuf is interesting from the fact that it is the probable ancient outlet of the great lake that once filled the Salt Lake Basin. At the head of Marsh Creek, which occupies the valley, continuing directly south from that of the Lower Portneuf, is the lowest pass between the Great Basin and the drainage of the Columbia. In fact, so low and flat is it that a marsh directly connects the two streams, one flowing to the Bear and the other to the Portneuf and Snake Rivers.

The bend of Bear River at Soda Springs is one of the most remarkable features of the whole district. Rising in the Uintah Mountains, Bear River flows northward for over two hundred miles, and at Soda Springs bends abruptly and flows southward toward Salt Lake. After it emerges from the gap west of Soda Springs, it flows out into a wide valley which opens directly into that of the Upper Portneuf. In this valley the divide between the two rivers is only a basalt plain, and in the eruption of this lava we may look for the clew to the extraordinary course of Bear River.

North of the bend of Bear River the mountains consist of isolated masses of Jurassic and Carboniferous rocks, the general strike of the rocks being northwest and southeast. There are several interesting folds in the rocks of this region.

The interesting springs at Soda Springs were carefully examined.

The latter half of the season was devoted to Bear River, Bear Lake, and Cache and Malade Valleys.

The Upper Bear River Valley has a wide drift-covered bottom. The hills on the east side soon develop into mountains as we go north. Formations from the Carboniferous up to the Wasatch Tertiary are represented, the latter resting on the upturned edges of the older rocks. On the west the same unconformability is seen, the area of Wasatch extending farther north. The beds consist of variegated sandstones and conglomerates. Bear Lake Valley has a range of low hills on the east, at the foot of which the lake leaves but a narrow margin. The waters of the lake occupy an area that is probably underlaid by several folds.

The Bear River Mountains are composed of Silurian and Carboniferous rocks, limestones, and quartzites. The edges of the strata face the east, but as we go west we soon cross a synclinal fold, the western side of which rises into high peaks on the east side of Cache Valley. The base of the range facing Cache Valley is Silurian. It is abrupt, and the basset edges of the strata give it extreme ruggedness. In the cañons of the streams coming from the range, saw-mills have been erected, and now supply the flourishing towns of the valley. Numerous lime-kilns also furnish them with a good quality of lime, the limestone being derived from the adjacent rocks.

There is but little doubt that the waters which once filled the Salt Lake Basin covered also the broad Cache Valley. The modern Tertiary deposits are found jutting against the mountains, and seem to pass gradually into the more recent deposits found in the central portion of the valley. The clays, sands, and marls of these modern beds are beautifully exposed along Bear River, which cuts its way across the northwestern part of the valley. On the west the mountains are broken or isolated ranges, which seem to have risen above the waters of the old lake as islands. The terraces are well marked on their sides, connecting with the Salt Lake Valley through the gap of Bear River.

West of this gap, and extending northward, is the Malade Valley. It is broad and filled with modern lake deposits. Silurian rocks outcrop on the east and Carboniferous on the west. At the divide between the Malade and Marsh Creek is another of the old outlets of the ancient Salt Lake when its waters were at the highest level. Although the area surveyed was large, (13,000 square miles,) good collections of fossils were made and data obtained for the elucidation of many interesting problems in relation to the age of the mountains. The entire district is of great interest to the geologist. Coal-outcrops were noted at a number of places on the Upper Bear River and its tributaries, and on some of the branches of Green River.

At one locality between Twin Creek, a branch of the Bear, and Harris's Fork, a tributary of Green River, there are some twenty-nine coal-beds, separated by sandstones and clays, the aggregate thickness being 315 feet. The beds of coal are from 1 foot to 48 feet thick. This locality has been called the "Mammoth Vein."

The area allotted for examination to the Sweetwater division, under the direction of Mr. G. B. Chittenden, covering atlas-sheet No. 57, is bounded on the east by the meridian 107°, and on the west by that of

109° 30′ of west longitude, and on the north by the parallel of 41° 45′, and on the south by that of 43° of north latitude, embracing a district of about 10,800 square miles.

In working this area, 171 principal topographical stations were made, besides some twenty auxiliary ones not numbered in the regular series. Between eighty and ninety stone monuments were erected on these stations to mark them permanently, while the peculiar topographical features of a great many others mark them with equal distinctness. While many of these, owing to the extremely desolated character of the country surveyed, are not likely ever to be used as initial points for the rectilinear surveys, there still will be many others which will be of very great value in giving starting-points for isolated pieces of rectilinear work, where fertile valleys and oases in this desert country are rapidly coming into demand by the settler. The most important of these fertile tracts are on the great southern drainage of the Wind River; the whole of the Sweetwater, with its southern tributaries; Sand Creek; the drainage of the old Seminole mining-district, and a series of lakes and springs south of the Sweetwater, near the latitude of Saint Mary's Station.

Into the first two of these districts (or a portion of them) a rectilinear survey was pushed this season by the measuring of a guide-meridian from the railroad, north, and the establishment of base-lines within the district. The guide-meridian had to be measured over about seventy-five miles of broken desert country, where water was extremely scarce and found only at long intervals. In the vicinity of all these fertile districts, particular pains were taken to give permanent markings to the topographical stations, and connections were made on two of the guide-meridian stakes, distant some forty miles from each other.

In continuance of the summer's work, the party took the field from Salt Wells Station, on the Union Pacific Railroad, on the 1st day of June, and completed the topographical work on the 25th day of September, in the vicinity of Fort Steele. Owing to orders, received at the beginning of the season, to complete the field-work by the 1st of October, and the very doubtful safety of a tract of low country in the north-eastern portion of the district, an area of about 800 square miles was necessarily left unworked in that portion of the district. The total area worked by the party, as nearly as can be estimated before the final plat is made, was 10,000 square miles. Careful notes were made on the grazing facilities, timber, and irrigability of the whole district, which will be more fully given in a later report. Taken in masses, an estimate of this area shows five-eighths to be desert country, two-eighths mountainous, and the remaining eighth valuable land. Giving these figures before the plat is made, they are of course merely estimates, but will afford an idea of the general characteristics of the country.

The weather throughout the entire season was much colder than that experienced at the same altitudes in Colorado, but the party suffered much less from rain, and in the four months of field-work did not lose one single day from bad weather, or indeed from any cause.

Dr. F. M. Endlich, Geologist of the Sweetwater division, states that within the area described above he found a well-diversified country.

A portion of the Wind River Mountains, in the northwest corner; the Sweetwater and Seminole Hills, toward the eastward, in ad lition to the lower bluff-country in the southern portion, furnished material at once full of interest to the student and to the surveyor.

After having surveyed that portion of the Green River drainage which

lies immediately outside of the mountains, the first halt was made at Camp Stambaugh. The party until then had passed through a region containing none but Tertiary formations. But little variation was found in the arrangement of strata, as well as in the distribution of fossil remains. Isolated volcanic eruptions of small dimensions produced prominent bluffs, far visible. These formed excellent landmarks, and were duly utilized as such. From Stambaugh, the party turned its course southward toward the Union Pacific Railroad. Here, too, the regular succession of Tertiary strata prevailed. The readily-disintegrating sandstones of the region have given rise to the formation of very extensive sand dunes. It may be observed that westerly winds are prevalent throughout that section of country, and, as the result thereof, we find them driving the sand to leeward and depositing it wherever the configuration of the country presents any obstacle to its farther progress. In this manner a "belt" of sand-dunes, about ten miles wide and fifty miles long, has been formed. Some difficulty was here experienced, occasioned by the sparing distribution of water. Only in springs and small alkaline lakes could it be obtained.

Red Desert Station, on the Union Pacific Railroad, was the point reached June 18. From there the party moved northward again toward Stambaugh, which place was reached July 3. Stambaugh is located within the area of the oldest metamorphic rocks of the district. In these metamorphics gold has been found during the last ten years in varying quantities, and the region was at one time the scene of considerable mining excitement. At present the mines have been to a great extent abandoned, and but little activity is noticeable.

Snow still covered a large portion of the Wind River Mountains, and it was deemed advisable, therefore, to carry on the explorations in some lower country until, late in the season, the mountains should be more accessible.

On July 5 the party left Stambaugh and marched toward the low valleys belonging to the Wind River drainage. The difference in elevation amounted to about 3,000 feet, and the temperature of the atmosphere was consequently much higher. While all the surroundings of the post were totally useless for agricultural purposes, the valleys of the Popo-Agies and their tributaries contained excellent farming-land. In spite of continually threatened raids by the Indians, a large number of settlers have taken advantage of the good soil and mild climate. With the change of elevation the geological formations change. Instead of the youngest beds resting directly upon the metamorphics, we now find a full series of the sedimentary formations, beginning with the Silurian. Numerous interesting stratigraphical phenomena were observed and studied with a view to determine their relations to the main mountain-chain. An ample amount of evidence has been obtained, more particularly by this means, to speak positively respecting the geological age of the Wind River Mountains. These latter, in this region, form the main Rocky Mountain chain, and the determination of their age will necessarily throw much light upon the same question arising in other portions of the same range. It will be possible to speak with a certain degree of precision of either the local, varying (as to time) elevation of the mountains or to refer it to one particular epoch for the distance of many hundreds of miles.

Camp Brown is located in the valley of the Little Wind River, which there is of considerable breadth. The famous hot springs there were examined. As the main peaks of the Wind River Mountains were mostly inaccessible from the east side, it was deemed advisable to make

the ascents of the highest from the west. Therefore the party traveled along the eastern foot-hills, through a very rugged country, until Stambaugh was reached.

July 22 the party again left Stambaugh and marched along the headwaters first of Sweetwater River and then of the eastern tributaries of Green River. Several of the highest peaks were ascended, and the greatest altitude reached found to be about 13,700 feet. This latter was on what the settlers generally designate as Frémont's Peak. From careful comparison of Frémont's report with the observations made by the party, it is evident that a misapplication of the name has been made, and that the peak in question is not the one ascended by that intrepid explorer of an "early day."

Having reached the northern limit of the district, the route was reversed and the western foot-hills of the main ranges examined. Here, as well as in the mountains proper, were noticed the remains of enormous ancient glaciers. Moraines, covering many square miles, often a thousand feet in thickness, extend downward through narrow valleys, now containing rushing streams. Striation, grooving, and mirror-like polish of rock *in situ* denote the course taken by the moving ice-fields that have left these marks of their former existence. From all appearance the cessation of glacial activity must have occurred within a comparatively recent time. Scarcely any vegetation has sprung up on the light glacial soil, and the characteristic distribution of erratic material bears every evidence of "freshness." Considering the enormous amount of snow and ice that was observed by the party exploring, (latter part of July and beginning of August,) the view was expressed by the geologist that the discovery of still active glaciers in that range would by no means be surprising.

Returning for the last time to Stambaugh, the route was taken in an easterly direction along the Sweetwater and its drainage. First, the adjacent drainage of the Wind River was surveyed, and the divide between the two streams crossed. All along the Sweetwater the characteristic "Sweetwater group" of Tertiary age was found to occur. It has been named and described in my former publications. This continued uninterruptedly until a series of hills north of the river, opposite Seminole Pass, was reached. These consist merely in projections of granite that during the Tertiary epoch, and probably long before that, had remained as islands above a widely-extended sea. Apart from their singularly unique character in this respect, the granite itself possesses a peculiarity that renders it at once conspicuous. Owing to the distribution of component minerals, this granite is in a high degree subject to exfoliation. Probably the main cause of this may be found in the action of freezing water. The result is striking. Instead of the rugged outlines usually presented by isolated granitic outcrops, we find a series of rounded, smooth, almost totally barren hills. To such an extent is this feature developed that many of them offer serious obstacles to ascent. A locality where the celebrated moss-agates occurred in great quantities was found in that region, and the geognostic horizon of these interesting quartz varieties was established. Marching southward, the party crossed the Sweetwater, and in the Seminole Hills once more encountered older sedimentary formations. Disturbances of enormous dimensions have here taken place, and render the study of the range one of extreme interest.

On August 29 Rawlins was reached and the provisions for the following month taken. From there the course lay northward, through low, dry country, where several alkali-lakes furnished water. Between two

of these, a short distance apart only, a rare occurrence was observed. Mud-springs, analogous to the mud-puffs of the famous Geyser region, covered about two square miles. Some of them were extinct, but most of them were still in action. By some force, which will not be here discussed, the water is caused to enter cylindrical orifices of varying dimensions. Inasmuch as this water contains in solution a large amount of mineral substances, and there is suspended in it a very large quantity of fine clay, evaporation produces a deposition of these materials. In this manner a cone is gradually raised, consisting of slightly arenaceous clay. So long as the force acting upon the water is more than adequate to the height of the cone, there will remain a circular opening at the top of the latter. When, however, this ceases, the result is simply a mound. About four hundred of these curious springs were found and examined. Great care was requisite, as the soil is very treacherous, and a mud-bath inevitable in case of breaking through.

The Sweetwater and Seminole Hills were examined during this trip and found to afford ample material for study. Stratigraphically considered, they may be regarded as being among the most interesting portions of the district. A satisfactory distribution of fossils in the various formations permitted all difficulties to be readily interpreted.

September 17, Dr. Endlich left the party and proceeded to examine the coal-bearing series and the mines near Evanston, Wyo. This was done with a view to present at an early date a report upon a subject which now has become one of vast importance.

On September 22 the party reached Fort Steele, and, having completed the work of the season, disbanded. Its members returned to Washington, there to prepare the maps and reports of the summer's work during the coming winter. Over 10,000 square miles were surveyed topographically and geologically during the time occupied in the field. Notes were obtained upon the geology, for the preparation of a geological map, and upon the agricultural and mineral resources of the district explored. A collection of Coleoptera and Diptera was made as complete as time would permit.

The district assigned to the Teton division, directed by Mr. G. R. Bechler, was situated between the parallels 43° and 44° 15′ of north latitude and the meridians 109° and 112° of west longitude. This area is drained by the branches of Shoshone or Snake River. The first portion surveyed by this division lies along the Blackfoot River and its tributaries. There are also some branches of Snake River, as Salt, McCoy, John Gray's, Fall, Antelope, Big Sandy, and Willow Creeks. Along the north side, and parallel to the Blackfoot River, is the Blackfoot range of mountains, with its higher portions toward the west, fronting the great plain of Snake River. In its southeastern continuation, near Gray's Lake, this range is reduced to a height of not more than 700 feet above the general level, so that it forms a low plateau divide; but south of Gray's Lake it rises until it attains a height of about 8,000 feet, about the sources of the Salt and Blackfoot Rivers.

Along the southwestern border of Shoshone or Snake River stretches another mountain ridge, reaching its highest point to the eastward, near Salt River, but diminishing in height as it follows along the lower cañon of Snake River, until it assumes more the character of a plateau, and finally terminates, near the Crater Butte bend, in a flat, terraced country.

Within this district Mr. Bechler made thirty topographical stations, over an area of about 10,000 square miles. There is in this district

a considerable amount of timber, mostly pine and poplar, (quaking aspen,) with a fair average of arable and grass land. The streams contain running water, even in the driest portions of the year. This region is especially adapted to stock-ranches, and must soon be occupied by herds of cattle.

After having completed the area described above, Mr. Bechler returned to Fort Hall for supplies, and then passed up Henry's Fork to the northern portion of the Teton Mountains, where he spent several weeks investigating this snow-covered range; then, crossing Pierre's Basin, surveyed the lofty group to which in 1872 he gave the name of Pierre's Hole Mountains. These ranges are characterized by as great ruggedness and inaccessibility as any other mountains in the Northwest.

During the past season the waters of Snake River and its tributaries were extraordinarily high, owing to an unusual amount of snow in the mountains, so that the party experienced much difficulty and loss of time in crossing the various streams. The fording of Snake River has always been difficult at all seasons of the year. The Snake and Grosventre Rivers flow through a broad and beautiful basin or valley, which separates the Teton from the Grosventre Range. The trend of the latter is southeast and northwest, nearly at right angles with the Teton group. The Grosventre Range, with the other parallel ranges to the south, of which Salt RiverRange is one, forms the dividing barrier between the waters of the Columbia and Green Rivers.

Fronting the Grosventre Range on the north rises another mountain cluster, separated from the former by the Grosventre River. This range forms the divide between the latter river and the Buffalo Fork of the Snake. It connects with the main Rocky Mountains near the sources of Wind and Grosventre Rivers and the Buffalo Fork of the Snake, and culminates near its western end in Mount Leidy. Mr. Bechler occupied two weeks in a careful survey of a part of the Grosventre Range, the entire Mount Leidy group, with the Upper Snake River Valley and its numerous interesting features.

North of the Buffalo Fork of the Snake, his observations extended into that densely wooded mountain region which connects to the north with the Mount Sheridan group, near the Yellowstone, Lewis, and Shoshone Lakes.

About the 1st of September he left the waters of Snake River, and marched along the rugged and densely timbered mountain spurs toward the Upper Wind River Pass, and, after crossing the latter, entered Wind River Valley, having the Owl Mountains on the left and the Wind River Range on the right. As he was about to cross over the Warm Spring Pass of the Wind River Mountains into the Green River Valley, to survey the southern ends of the Grosventre and Salt River Ranges, he received a notice, through Indian scouts, from the commander of the military post at Camp Brown, to leave the country, on account of the danger of hostile Indians. On this account nearly a month of valuable time was lost, abridging somewhat the results of the season's work. Notwithstanding the various difficulties which this party encountered, they surveyed an area of about 6,000 square miles of the most rugged mountain country in the Northwest, and made one hundred and ten reliable observations with the mercurial barometer. Mr. Bechler, throughout his district, personally observed 7,340 horizontal angles and 5,700 angles of elevation and depression; and as they repeated backward and forward, and were checked by good barometric

readings, they must give satisfactory results as to the altitude of that extremely mountainous country.

The following is a summary of the results of the geological investigations of Mr. Orestes St. John, geologist of the Teton division:

Commencing with the area assigned to the Teton division of the survey at its southwestern corner, the first five weeks were devoted to the examination of the region lying in the great northern bend of the Snake River, and which includes an area of 1,700 to 2,000 square miles.

This section consists, topographically, of a series of more or less parallel low mountain ranges, of which the three principal ones are, the Mount Putnam Range, on the southwest, and which extends southward into the adjacent district; the Blackfoot Mountains, in the central portion; and the Caribou Range, which embraces a rather wide belt of broken hill country and low mountains along the eastern border, and which culminates in Mount Bainbridge. These ranges have a general direction west of north and east of south, and are separated by broad, shallow depressions, in the midst of which occur other lesser parallel ridges. To the north these low ranges die away in the great plains of the Snake Basin, which comprise about one-third the area of the section here referred to.

The Snake plains are everywhere floored with basaltic rocks, which were met with in the extreme southwest portion of the district, along Ross Fork, at the western foot of Mount Putnam. To the northward, in the debouchure of Blackfoot River, these rocks rise high up on the flanks of the hills bordering the plains, where they attain elevations of 600 to 800 feet or more above the level of the plains, toward which they incline in great benches or foreland slopes. Similar occurrences of basalt are found at various points along the northern border of the hill country; the northern termini of the Blackfoot and Caribou Ranges exhibiting similar benches, inclining in long, gentle slopes to the general level of the Snake plains. These basaltics penetrate all the principal valley depressions opening to the southward, forming extensive inlets which occupy ancient valleys of erosion in the sedimentaries. The Blackfoot Valley and the valley depressions between the Blackfoot Mountains and the Caribou Range are floored with basaltics in every way similar to the deposits occurring in the Snake plains, and which extend up these valleys to the southern boundary of the district, flooring wide, basin-like expanses into which these depressions open out toward their sources. In this manner the Blackfoot Mountains are surrounded, as it were, rising in the midst of a basaltic sea, as also is the case with other sedimentary ridges in this region.

The vertical extent of these basaltic flows, which doubtless represent several distinct epochs of eruption, it is impossible to decide with any degree of accuracy, though they are here seen to reach a thickness of several hundred feet. The extent to which they have suffered erosion is enormous, for it is undoubtedly true that they once in many places reached high up on the flanks of the insular mountain ridges, but where to-day not a trace remains to show their former presence. Yet there are a host of phenomena bearing on the present occurrence and extent of these deposits which require thorough examination into before we can present even a general statement of the facts which may finally lead to the elucidation of the history of this member of the volcanic series in this region.

These basalts extend up the valley of the Snake as far as the lower basin, where they are succeeded by other volcanics. These latter, mainly trachytic materials, are far less conspicuous in the area of their

exposed occurrence than the basalts, and are usually met high up on the sides, and even crowning some of the highest mountain crests. They are always observed to incline at greater or less angles, and when seen in the ridges along the northern border of this region, they dip in the direction of the Snake plains. They appear to be more ancient than the basalts, their connection with which cannot now be clearly determined. Toward the northern terminus of the Caribou Range, in some of the highest crests in that quarter, these deposits are seen to be underlaid by a heavy mass of water-worn bowlders and pebbles, cemented with a fine paste. This deposit is not clearly stratified. And again, within the lower basin of the Snake, (that marked "prairie-bottom" in 1872 map,) similar pebble deposit is imbedded with alternations of laminated trachytics and compact lava-basalt, which together make up a thickness of several hundred feet, gently inclining toward the center of the valley, forming a sort of low foreland along the base of the mountain, against which the volcanics abruptly impinge. In the valley of the Blackfoot, where the party met with isolated areas of trachyte, a heavy mass of conglomerate of a similar appearance occurs, associated with sand, and dipping in the east side of the valley at a moderate angle toward the Blackfoot Mountains. It differs, however, from the before-mentioned bowlder-bed in being made up of a greater variety of more or less abraded material, including pebbles of trachyte and lava-basalt, indicating its more recent origin.

Rhyolitic and other volcanic products were found at a few localities in the region. In one instance the eruptive matter appears as a dike in the crest of a low, short ridge (station 17) between the Blackfoot and Caribou Ranges, its eruption having tilted the sedimentary deposits into an anticlinal ridge. Again, in Mount Bainbridge, (station 28,) very interesting phenomena were observed in connection with these rocks. The mountain is a monoclinal ridge, made up of sedimentaries, between whose strata the igneous matter is intruded, appearing like veritable beds of deposition, seen from a distance, while the bulk of the west portion of the mountain appears to consist of an enormous mass of eruptive matter thrust up from below. Mount Bainbridge would seem to be another instance of local outburst of volcanic material similar to those brought to light by the survey in Western Colorado. In the course of the prosecution of the examinations in the volcanic rocks of the district as complete suites were secured of the various kinds of these rocks as it was practicable to transport, and which, together with the notes, will afford the materials for an interesting chapter on this subject.

The Mount Putnam Range proper is a monoclinal ridge, made up of ancient quartzites and slaty schists, followed by Quebec and Carboniferous limestones, dipping generally to the eastward. The angle of inclination is very variable, as is also the strike of the strata. In the high peak on which station 1 was located the mass of the strata is quartzite, which in places stands vertical or even overturned and dipping westerly at a steep angle. These rocks, together with the schistose beds, constitute the exposed ledges occurring in the western side of this mountain, while to the east, doubtless, the Silurian and Carboniferous beds successively appear in the lower declivities. But in the low ridge which forms the northern extension of the Putnam Range proper these ancient quartzites gradually pass out into the plains, where they are eroded and concealed beneath detrital accumulations and late volcanic Tertiary, (the latter described by Bradley;) while the ridge itself, as its trend curves more and more round into the northeast, is crested, first, by the Quebec limestone, and then by Carboniferous limestones, fol-

lowed by obscure exhibitions of the Triassic, and finally the Jurassic deposits. All these deposits in this quarter succeed each other with apparent regularity, with dips generally varying from 25° to 45°, but the strike gradually passes more and more to the west of north as we pass along this ridge in that direction, and which, together with evidences of extraordinary local disturbance, is still more manifest in the low range of hills next east and lying between Lincoln Valley and Blackfoot River.

This latter region embraces a belt of low hills and ridges which culminate to the north in Higham's Peak. Its northern extremity is covered by the upraised volcanic, through which the Blackfoot has cut a deep cañon, in which these latter deposits are finely displayed. As it will have inferred from the foregoing brief notice of the distribution of the volcanics, the basalts occur all along the eastern flank of these hills, as far south as the bend in the Blackfoot. The southern portion of this belt of hills is connected with Mount Putnam by a series of interpolated ridges, defining the water-shed between the Portneuf and Ross Fork drainages.

This belt is made up of Carboniferous limestones and siliceous deposits, Triassic sandstones, and Jurassic limestones and shales. In the southern portion of the belt these deposits occur in a rather shallow synclinal, defined on the east and west by the Carboniferous beds. But in the middle and northern portions these strata are complicated by displacements and foldings to such an extent as to render their study an exceedingly difficult undertaking. Here the geologist encounters the most conflicting manifestations of disturbance in the constant variation of dip and strike exhibited by the beds, and which, even in short distances, change from moderate inclination in one direction to vertical and inverted position; while the strike exhibits in the flexures of the strata all those irregularities which may be attributable to violent upheaval. None of the later members of the Cretaceous were identified in this region; but in the low border hills to the north of Fort Hall occur extensive deposits of yellowish and light-red sandstone, which may prove to belong to the earliest epoch of this period, though no certain evidence on this point was gained, more than that on the slopes outlying Higham's Peak on the west these beds overlie Jurassic limestones.

To the southeast, in the region of the southern bend of the Blackfoot River, to the west, but somewhat isolated from the above range of hills, in low isolated hills, and apparently also making up the bulk of low ridges intervening between the Blackfoot and a shallow basin next east of Lyncoln Valley, an extensive deposit of light-colored calcareous material was found, indurated layers of which contain great numbers of molds of gasteropods, identical with those occurring in similar deposits in the region of the debouchure of Bear River, and which have been referred to fresh-water forms of the Pliocene. These beds dip 25° east of north, and are overlaid by trachyte, also inclining northeast at an angle of 15° to 20°. Station 30 was located on one of these volcanic-capped Tertiary buttes. To the west of these Tertiary hills occur the conglomeratic deposits, dipping from northerly east, and finally southeast 10° to 20°, whose components show it to have been formed subsequent to the eruption of the volcanics, although these coarse materials are included in a fine paste which may be of volcanic origin. In this place mention should not be omitted of the existence of a low anticlinal axis or fold in the volcanics which occupy the Blackfoot Valley. From all a hasty trip reveals, it seems certain that this region has been subjected to intense volcanic action in comparatively recent times.

The Blackfoot Mountains are mainly composed of Carboniferous strata, which occur in a well-defined monoclinal ridge, but which really forms the remnant of an anticlinal fold, the axis of which lies about the middle of the range, the strike bending in and out but always crossing the range obliquely; to the north the beds dip off to the southwest, and to the south inclining northeasterly. Blackfoot Peak is a high culminating point on a sort of spur to the northeast of the main range, beyond which occur areas or belts of variegated early Mesozoic deposits. In the southern portion of the range, on the southwest flank, a considerable thickness of brown arenaceous and limestone deposits comes to view from beneath the Carboniferous beds, where they are seen to form the axis of the anticlinal fold. These deposits contain a meager fauna, which appear to be referable to Silurian forms. The Carboniferous mainly represents the earlier period, whose epochs are indicated by similar paleontological peculiarities which distinguish the Lower Carboniferous formations in the Mississippi Basin, and which more extended research will doubtless reveal in this distant region. But one of the most interesting discoveries in this connection was the presence of fish-remains, representing several forms identical with or closely allied to Keokuk species of the genera *Cladodus*, *Petalodus*, *Anthiodus*, *Helodus*.

Between the Blackfoot Mountains and the Blackfoot River, and occupying the angle in the southern bend of the Blackfoot, an isolated area of hills exhibits a series of strata, including the Upper Carboniferous on the north to the Jurassic on the south. The middle portion of this section is much disturbed and the exposures unsatisfactory. The former beds incline steeply southward, while in the Jurassic ledges on the south a marked anticlinal fold is observed, the strata inclining to the north and south either side of the axis. Stations 12 and 13 were located on ridges on the north side of this fold. The beds in this group of hills have veered round so as to have nearly east and west strike.

To the southeast of the Blackfoot Mountains, from which they are separated by a wide basin-plain floored with basalt, rise a couple of low parallel ridges lying between John Gray's Lake and the upper basin of the Blackfoot River. The northeastern flank of the eastern ridge shows red sandstones, probably Triassic beds, and similar deposits occur on the opposite flank of the western ridge. Their present condition is that of monoclinal ridges, the strata of which show northeasterly and southwesterly dips, respectively. The eastern ridge shows the basalt reclining high up on its southwest flank, resting on the Carboniferous limestone near the crest of a sag in the ridge. Both ridges are, however, principally composed of Carboniferous limestone and siliceous beds.

East of the Blackfoot Mountains, the first low mountain eminence encountered appears to be a bulging up of the volcanics, the basalts rising up on the flanks of the ridge, whose summit is composed of scoriaceous lava. To the southeast the basalt has been denuded, leaving several low buttes of this rock, which seems to be connected with the deposit which fills the broad valley separating this from the Blackfoot Mountains. (Station 4.) But to the northward, beneath the basalt, the nucleus of the ridge displays a series of soft gray sandstones and harder red, coarse sandstones, with variegated shales, underlaid by drab-gray limestone containing great numbers of a small gasteropod, and which is in turn underlaid by hard light-red sandstones. These beds incline southwesterly, and together they represent a great thickness of strata. The ridge on the north is capped by trachyte, which dips at a steep angle into the Snake plains. The upper sandstones contain obscure vegetable remains, from which circumstance their Cretaceous age may be in

ferred. The limestones and sandstones are again exposed to view in a low anticlinal ridge next east, which was thrust up by a rhyolitic (?) dike, on which station 17 was established. The limestone is also here charged with the same little gasteropod, and underlies the sandstone, which latter shows obscure plant-remains. The dips at the latter locality are southwest and northeast.

To the southeast of the above locality, in the vicinity of Gray's Lake, obscure outcrops of reddish and gray sandstone may be seen in a cluster of low hills just to the south of the lake. These beds dip at moderate angles to the southwestward, and on the westernmost low ridge among the *débris* an obscure *Ammonites* was found preserved in a fragment of gray limestone. It is uncertain whether these beds should be referred to the Cretaceous or Jurassic; but the fossils obtained will doubtless readily establish their age. To the west these beds are doubtless suddenly and sharply folded, as the Carboniferous appear in the beforementioned pair of ridges just west of Gray's Lake and but a few miles from the above-mentioned exposures with *Ammonites*.

The Caribou Range occupies by far the largest area of any range in this region, and in its geological aspects it is also the most varied. Along the northeastern border at intervals, or near the northern extremity and again between the lower and upper basins in the Snake Valley, the range is flanked by heavy deposits of quartzites which resemble the ancient quartzites in Mount Putnam. This is succeeded by the Carboniferous, consisting of limestones and hard quartzitic sandstones, in the upper portion of which occurs a horizon charged with a peculiar lamellibranch fauna, which strongly recalls the Permian. This latter probably represents the equivalent of the Permo-Carboniferous in this region. Next in order of superposition is a thickness of several hundred feet of "red-beds," which is in turn overlaid by the peculiar light drab, indurated, calcareous shales and limestones of the Jurassic. Along the western border of the range, to the north, occurs a heavy series of reddish and soft, gray sandstone, imbedded with variegated shales, which contain vestiges of a flora represented by obscure impressions of woody stems and dicotyledonous leaves, (between stations 19 and 20.) Higher in the mountain slope these deposits are overlaid by gray and drab limestones, which afford a few small ostreas and the pentagonal disks of crinoid columns. The former deposits can hardly be referred to a more ancient period than the Cretaceous, while the latter as probably belong to the Jurassic; the relative position of the beds indicating a fold which overturned or inverted the strata. These or very similar gray sandstones were met on the eastern flank of Mount Bainbridge, where they are followed above by dark shales, here much changed by contact with the intruded volcanics and the limestone cap of the mountain, which latter afforded traces of a little gasteropod, apparently similar to those occurring in before-mentioned limestones found elsewhere in connection with these gray and reddish sandstones. The general strike of these strata is northwesterly and southeasterly, though subject to great variation even along the same line of exposure in crossing the series; while they are much folded, which greatly complicates their study, rendering accurate measurements impracticable in the hurried examinations made. There are three or four conspicuous folds, one of which is a sort of double fold, which at one point shows an abrupt flexure in the strata involved which may at other points have completely severed the bed, resulting in a fault. As already intimated, the region is further complicated by inverted beds, and in certain parts there are found the most contradictory dips, indicating a chaotic condition, the result of intense

local disturbance. The vertical displacement is very great, and the amount of material which has been removed by erosion, and this, too, within a comparatively not remote date, is almost inconceivably great.

Allusion has already been made to the Mount Bainbridge volcanics, where these igneous products are so intruded in the limestones and shales as to present the appearance of regularly-bedded deposits. Associated with the eruptive rocks at this locality are auriferous lodes of some richness, which have given a fair supply of gold to the placers, though as yet little has been done toward developing the lodes themselves. It is presumable that all the placer diggings in the Caribou district received their gold from the lodes intersecting Mount Bainbridge. The intrusion of this great mass of eruptive rock does not appear to have greatly disturbed the sedimentaries, since the southwesterly inclinations observed in ascending the eastern slope of the mountain are continued down the opposite slope and as far as Gray's Lake Basin, the only change of note being the gradual flattening of the angle of inclination as we recede from the range westerly. While the Carboniferous deposits appear to be mainly, if not wholly, restricted to the northeastern border of the range, the Jura-Trias composes the bulk of the central portion, with belts of the variegated shales and sandstones of later date in the southwest; all of which share equally in the effects of upheaval, which has folded and warped these deposits in a remarkable manner.

There remains to be noticed the occurrence, in the upper basin of the Snake Valley, extending up to the debouchure of the grand cañon, of a peculiar deposit of variegated clays and partially indurated sands, which fill this part of the valley. These beds are extensively exposed in the right bank of the Snake River below the confluence of Salt River, and also may be seen in the opposite side, that along which the party traveled, and where their tilted edges are planed off to various terrace-levels, marking the work of the river erosion, and the whole overlaid by the coarse materials out of which the more modern terraces were formed. These beds incline quite uniformly obliquely up stream, or in an easterly direction, at angles of 35° to 40°. Their tilting it is difficult to account for, since they are unconformable to the older formations in either the east or west side ranges bordering the Snake Valley; and yet it seems almost certain that they owe their present position to disturbances lying to the westward, in which case it may enable the determination with a good degree of accuracy the precise age of at least (if there be more than one such) the latest upheavals which have taken place in the Caribou Range. I take it these valley deposits are of late origin, probably Tertiary lacustrine beds.

Below the mouth of Salt River occur extensive deposits of calcareous tufa, jutting out into the valley in low platforms, in the neighborhood of which saline springs are flowing feebly to-day. Again, in the little basin-valley east of Lyncoln Valley, quite extensive calcareous deposits floor the valley, in the midst of which are vestiges of the now extinct springs from whose flow this material was precipitated. The little streams which rise in the Blackfoot Mountains also contain much lime, which is deposited on stones and sticks in the beaver-dams in their lower courses. But none of these accumulations are comparable to the enormous spring-deposits met with in the northeastern foot of the Wind River Mountains, in the upper portion of the Wind River Valley, which were hastily examined later in the season.

Reference has been made in the foregoing pages to the evidence bearing on the age of some of the disturbances which have taken place in

the Caribou Range, and which would appear to have taken place at a comparatively modern date, or subsequent to the deposition of the Tertiary lake-beds. In the valley of the Blackfoot are found a set of loose sand and conglomerate deposits, which are apparently of later date than the period of basaltic effusions, and which were tilted by forces lying to the westward, the beds dipping toward the Blackfoot Range. Hence, it is reasonable to infer that these deposits, together with the Pliocene shell-beds in the same quarter, were tilted at the time of the disturbances which folded and complicated the strata in the belt of hills lying between the Blackfoot and Lyncoln Valley, and which does not appear to have affected the Blackfoot Mountains, whose elevation is probably referable to an earlier date, or late Mesozoic time.

In conclusion, it may not be out of place to mention the beautiful scenery of this region, its grassy hills and plains, and its many tracts of arable land adjacent to the numerous little streams of pure water which drain the region. For the purposes of stock-growing the country offers many inducements. Save in the plains bordering the Snake River, where excellent crops of small grain and vegetables are grown, we have not the aid of experiment to guide to positive information respecting the agricultural capability of the tracts of fertile valley-soil everywhere found, and which can be easily irrigated. But even in the high basin, or mountain valley, in the Caribou district, oats and the hardier vegetables are grown. There is a scarcity of wood, and the largest forest tracts are generally in the most inaccessible localities.

That portion of the district next visited comprises ground which was partially explored by the expedition of 1872. Hence, during the limited time the present party spent in this region, it was principally the geologist's aim to visit those quarters which had not previously been examined. This region embraces all that portion of the district lying in the great southern bend of the Snake River, extending northward to the northern boundary, and in area more than a third greater than the previously noticed region lying to the southwest. The whole northern portion is occupied by the plains of the Snake Basin, which in the west and northwest are interrupted by a cluster of low volcanic cones, surrounded by sand-hills. On the east the plains rise into the broad ridge which slopes off from the northern end of the Teton Range, and which merges into the low, densely-wooded water-shed separating the Henry's Fork drainage on the west from the upper waters of the main Snake River on the east. The entire extent of the plains region, including the before-mentioned low water-shed, is immediately underlaid by volcanic rocks. A vast sheet of lava-basalt is spread over the extensive lower levels of the plain. In the sloping upland border region to the south, these basaltic rocks are succeeded by a laminated variety, associated with trachytic material, which gently rise upon the flanks of the highlands to the southward, precisely in the manner observed in connection with the volcanics in the southwestern portion of the district. Pierre's Basin, which lies between the Teton Range and the northern portion of the Snake River or Pierre Mountains, forms a sort of estuary, opening out north into the Snake plains, up which the laminated and trachytic volcanics extend—on the east side as far as the mouth of Teton Pass, and on the west side about half the distance toward the head of the basin. Formerly, doubtless, the entire area of this basin was floored with these rocks; but to-day they are only observed in isolated patches, reclining on the foot of the surrounding mountains, while in the valley they are covered by Post-Tertiary deposits of water-worn gravel and bowlders and the silted washings from the surrounding

slopes. To the north of West Teton Creek, however, the volcanics constitute a prominent feature in both the basin plain and in the foot of the mountains. They are here seen to rise up on the flank of the range to an elevation of 2,000 feet above the basin, forming a wide, heavily-timbered foreland, lying between the mountains and the plain. In this border region the streams are deeply cañoned.

In Pierre's Basin, as also in the bottoms along Henry's Fork and its tributaries, accumulations of water-worn drift materials are prevalent, mainly consisting of quartzite bowlders, with more rarely limestone, granitic, and volcanic bowlders; the three former varieties derived from ledges in the Teton Range and the mountains to the south and west. These drift materials were also occasionally observed in the uplands, where they are weathered out in the slopes immediately bordering the cañoned courses of the streams; showing their general distribution over the entire area of the volcanics, as well upon the sloping upland as in the river-bottoms. Indeed, on some of the high crests in the northern part of the Teton Range, quartzite and gneissose bowlders are sparsely present in situations where their presence cannot be accounted for satisfactorily without the intervention of glacial transporting agencies.

A march of eight days' duration from Fort Hall brought the party to the Teton Mountains, near the northern end of which, on the west side, the first ascent was made. This range, in its present condition, may be described as a gigantic monoclinal ridge, with a metamorphic and granitic nucleus which forms a lofty, exceedingly rugged, jagged crest, extending in a north and south direction three-fourths the length of the range, and which culminates in Mount Hayden. The eastern face is suddenly broken down in precipitous walls and steep slopes, which descend into Jackson's Basin. The western slope throughout its extent is covered by the sedimentaries, dipping to the westward at comparatively moderate angle of inclination. About midway between West Teton Cañon and the northern terminus of the range, the continuity of this sedimentary foreland is suddenly interrupted by a rugged spur of Archæan rocks, thrown off from the main range to the east, and which separates the sedimentary area into two portions. The northwest terminus of this spur reaches quite across the belt of lofty summits outlying on the west the Archæan belt, the volcanic ledges lapping up on its foot, and beneath which the sedimentaries are concealed. The structural features of the range, so far as relates to the sedimentaries, are comparatively simple. To the north, where the volcanics reach high up on the western flank, in one of the cañoned sources of the North Fork of Pierre's River, the lowest ledges *in situ* consist of a considerable thickness of thin-bedded drab limestone, which I take to be Quebec. Above this occurs a heavy ledge of buff magnesian limestone, showing a thickness of 100 feet or more, and which contains obscure corals resembling Niagara forms. Above the latter, to the summit of the high ridge on which station 32 was made, occurs a thickness of 1,500 feet of Carboniferous deposits. At this point these deposits show a gentle inclination northwesterly; but to the north, at the base of the same mountain, the northeasterly dip of these strata indicates a synclinal depression at this point. Beyond, in the same directiod, and near the terminus of the range, the strata are steeply tilted or upturned, with sharp westerly dips, as though the result of the upheaval of the Archæan ridge which lies just to the east. From such observations as Mr. St. John was able to make, it appears that the sedimentaries which may once have folded continuously round the north extremity of the range, were extensively denuded prior to the eruption of the volcanics, which overlap alike the

sedimentary outlying deposits and the Archæan areas, wherever the latter reach the western and northern borders of the range. To the south of the above-mentioned Archæan spur, the same series of sedimentaries recur, and which extend high up on the more elevated portions of the range, sloping thence to the westward in the direction of Pierre's Basin. But to the south of the West Teton Creek Cañon, a series of deep red arenaceous shales and sandstones are superimposed on the Carboniferous, the capping of intensely hard siliceous rock or quartzite forming an effectual protection to the foreland, which here sweeps down in long, comparatively regular slopes into the valley. These latter deposits here show a thickness of 300 to 500 feet. On the lower slopes of the foreland, apparently overlying these red-beds, obscure traces of drab limestone, not unlike Jurassic deposits found elsewhere in the district, occur. Though no fossils were observed in these beds, it will at once occur to you that they are probably Triassic. These red-beds form a conspicuous feature in the magnificent escarpments thence southward nearly to Teton Pass Creek, where they have been denuded, the Carboniferous beds again appearing in the base of the mountains. In passing southward along the west flank of the range, the inclination of the sedimentaries is observed to gradually change from a north of west to west and southwest direction. In the vicinity of Teton Pass, to the southwest, are evidences of unusual disturbance, the Carboniferous beds being suddenly upturned, forming what appears to be a short, sharp fold, with steep easterly dip and more gentle westerly inclination. The pass itself is eroded out of the "red-beds" and siliceous upper deposits of the Carboniferous. While obscure exposures of brownish-gray limestone containing a small ostrea-like shells and soft gray sandstone indicate the presence of the Jurassic, and probably the Cretaceous, which seem to occupy a synclinal depression whose axis deviates more to the east of south from the prevalent strike of the sedimentaries in the Teton Range, and in this respect corresponding intimately with the folds afterward observed in the mountains on the west side of Pierre's Basin.

The Teton Range terminates rather suddenly in lofty peaks sculptured out of the sedimentaries, to the south and southwest of which a much lower but very broken mountain tract extends to the grand cañon of the Snake River. This tract is crossed by broad belts of "Red Beds," drab and buff beds, corresponding to the Triassic, Jurassic, and, possibly, Cretaceous, and which are limited in the distance by rugged crests composed of gray ledges, which may prove to be the Carboniferous basin bounding the Snake River. The high peaks which rise immediately to the north of Teton Pass summit are made up of Carboniferous strata, dipping a little north of west at angles of 10° to 45°; to the west, however, the same deposits incline at much steeper angle, as noticeable in the acclivities on the north side of Teton Pass Creek. These ledges sweep up over the summit of the range, forming lofty ridges which break down abruptly on the east in a succession of escarpments and steep *débris* covered slopes. East of the summit of Teton Pass, in descending to Jackson's Basin, the granitic nucleus cannot lie far beneath the bed of the cañon, since the short northern tributary cañons have brought down much granitic *débris;* but below this still, in a bulky outlying ridge at the debouchure of East Pass Creek, the Carboniferous again appears, also dipping north of west at a moderate angle. Farther north, in these east-facing sedimentary escarpments, where the whole series of Palleozoics occurring in this region is revealed in magnificent exposures, a fold or undulation in the strata is observed by which the Carboniferous beds are carried down along the east slope to a level far below the lofty sum-

mits which the beds crown along the crest of the range; a similar fold would explain the occurrence of the low-lying exposures in the debouchure of East Pass Creek, above noticed. Beneath the sedimentaries at this point the Archæan rocks are exposed, and which descend in steep, rugged slopes to the level of the valley. To the north still, the Archæan nucleus rises higher and higher, carrying up with it the sedimentaries, which gradually disappear, one formation after another, until only Quebec is seen, forming a coping of dark limestone to some of the high ridges south of Mount Hayden, and where they are finally crowded back, occupying subordinate ridges west of the main crest. The east face of the range from the vicinity of the Tetons to its northern extremity shows only the Archæan rocks. It is very probable that the sedimentaries were profoundly faulted along the east side of the range, along which side, it would appear, the greatest force was expended in the upheaval. But toward the extremities of the range, where these forces were less violent, the sedimentaries may have been merely crumpled or folded in the manner apparent in the southern extremity of the range.

Subsequent erosion has greatly changed the surface contour, and obscured many details, but the general features are still manifest.

A brief visit to the Pierre Mountains, on the west side of Pierre's Basin, afforded opportunity for the study of the structural features of the eastern half of the range. This range intersects the Teton Range at a sharp angle, its general direction being northwest and southeast, and forming an exceedingly broken mountainous belt between Pierre's Basin and the Snake River. In its geological structure it is intimately related to the Caribou Range on the opposite, west, side of the Snake River. The range exhibits a series of folds, whose axes extend in a general direction northwesterly and southeasterly, and in which are exposed typical exhibitions of the Carboniferous, Triassic, and Jurassic, and probably the Cretaceous formations. Along the eastern border, toward the northern extremity of the range, in a section much complicated and broken up by the forces which folded the beds, occur a series of gray sandstones and shales which closely resemble deposits found in the Caribou Range, which have been referred to the Cretaceous. These beds appear in low ridges, upon which lap the volcanics in long, gentle ascents from the cañon-scored plain of Pierre's River to the northeast and north. To the southwest a wide belt of Carboniferous is met, showing the entire thickness of the formation, which is made up of limestones and heavy siliceous deposits. On the southwest side of the anticlinal in which these limestones are exposed, a heavy series of deep red gritty shales and sandstones, reaching a thickness of 1,500 feet or more, occur, which represent the Triassic. Succeeding the latter, occur a set of beds made up of limestones and drab indurated calcareous layers, with Jurassic fossils, representing a thickness of a thousand feet or more. These are followed by a series of heavy deposits of hard sandstones and variegated clays, resting upon a heavy ledge of conglomerate near the base. To the southwest, occupying the intervening belt lying in the heart of the range, a labyrinth of deep cañons and sharp ridges, similar deposits are here and there indicated, bounded in the distance by the more uniform and even loftier mountain wall along the northeast margin of the Snake Valley, which appears to consist of Carboniferous strata. These several folds, so far as I was able to determine, are pretty constant for long distances. Although the middle part of the range has been much eroded, so as to cause the Carboniferous to flank the mountains between Horse Creek and the head of Pierre's Basin, the outer belt of Cretaceous near the northern end of the range probably

belongs to the same fold which lies just to the southwest of Teton Pass; while the inner folds above alluded to correspond to those observed in the southeastern half of the range to the southwest of Teton Pass. The condition of the sedimentaries in the interval embraced to-day in Pierre's Basin, of course remains conjectural, these rocks being hidden from observation beneath the volcanic sheet which at a later date flooded the valley. From the relative age of the folding of the strata which make up this range, compared with other neighboring ranges, it seems probable that the date of its upheaval is referable to a time antecedent to that during which the disturbances took place which resulted in the folding of the Caribou Range, and probably subsequent to the upheaval of the Teton Range. This latter forms a unique as it is one of the grandest ranges in the West. In many particulars it bears a more striking resemblance to the Wind River Mountains than it does to the low but much more complicated ranges which it dominates.

That which forcibly strikes the observer on entering Jackson's Basin, which lies at the east base of the Teton Range, is the vast accumulation of drift materials with which the valley is filled. Along the west side of the basin extensive morainic accumulations in irregular, wooded ridges, outlying the debouchures of the cañons which penetrate the range; while the stream itself, in various stages, has fashioned these materials into beautiful terrace formations. Scarcely anything could offer greater contrast than that presented by the mountain environments of this basin. The Teton Range forms a rugged, almost precipitous barrier on the west, which rises 4,000 to 7,000 feet above the valley. To the east the country rises in gentle, wooded ascents, culminating in clusters of low mountain elevations which are connected by high mountain plateaus with the continental water-shed. To the southeast of the Teton range, and running up into the angle formed by the confluence of the Snake and Grosventre Rivers, lies a rather lofty and very rugged range of mountains which occupies a considerable area between the Grosventre and the headwaters of Green River, and which forms a sort of transverse belt connecting the Teton Range with the Wind River Mountains to the east. This range is known as the Grosventre or Wyoming Mountains. The geologist's examinations were confined to the western portion of the range. Here he meets with an Archæan (gneissic) nucleus, which in places penetrates through the heavy mantle of sedimentaries in sharp peaks which but for the presence of the colossal Tetons would elicit admiration for their real grandeur and perfect mountain contour. In many respects the range presents marked resemblance to the Teton Range, and probably its relationship to the Wind River Mountains is even more intimate. The sedimentaries have been uplifted bodily upon portions of the range, though they exhibit evidences of great disturbance and of the unequal distribution of the elevatory forces, which have in places sharply folded the strata. One of these Archæan peaks sends down a sharp spur to the westward, which terminates rather abruptly in the valley at a point about opposite the Lower Grosventre buttes. Between the latter and the foot of the spur, a little stream has excavated a widish valley, in the west side of which, in a line of bluffs, dark weathered ledges appear, gently dipping westerly, and which are probably Quebec. In the northern butte, Professor Bradley mentions having observed volcanic ledges ("porphyritic breccias,") and to the south limestones in horizontal position, which are referred to the Carboniferous. The volcanic capping gradually rises to the southeast, and finally disappears. A similar remnant occurs on Elkhorn Creek, near the edge of the basin, where it rests upon Tertiary deposits. To the north of the above-mentioned spur, in

the foot of the foreland, outcrop ledges of thin-bedded drab limestone, dipping northwesterly, which are undistinguishable from the Quebec limestones occurring in the Teton Range. Ascending this foreland, eastward, the same limestones are exposed at frequent intervals, showing the same dip, and in places overlaid by remnants of the buff magnesian limestone referred to the Niagara. These deposits finally give way to densely wooded *débris* slopes, which reach up to the Archæan peak of station 44, like gigantic moraines. From this point an excellent opportunity is had for the study of the rugged and almost inaccessible mountain highlands which make up the broad northern summit of the Grosventre Range. It is a region of lofty ridges and profound amphitheaters, whose precipitous walls exhibit the complete sedimentary series from quartzites to the Carboniferous, and off to the east heavy deposits of the Triassic "red beds" cap high ridges. The region strongly recalls the Teton Range, but the sedimentaries are much more disturbed, and, as a consequence, this highland is more uneven than that along the west summit of the latter range. A few miles to the northward, the foreland which rises into station 46 from the debouchure of the Grosventre, exhibits the Carboniferous dipping northerly, and which extends to the summit of this lofty peak. These beds pass beneath the Triassic, which appears in line of vermillion bluffs along the north side of Grosventre Cañon, beyond which the hills gradually rise into a high conical peak which forms the culminating point of the highlands between the Grosventre and Buffalo Fork, and which is known as Mount Leidy. Overlying the Triassic red beds, a broad belt shows light drab deposits which also dip northerly, and which hold the position and have the appearance of the Jurassic, though no fossils were observed in the limestones, which in part make up these latter deposits, by which their age could be determined. The space intervening between the latter deposits and Mount Leidy is more broken, and apparently consists of an extensive accumulation of softer deposits. The lower portion of these are found to consist of light and yellowish soft sandstones and clays, capped by light-brownish beds, which are finely displayed in Mount Leidy, whose steep slopes the elements have beautifully sculptured. In the northern foot of Mount Leidy, the lower or middle beds of this series exhibit an exposure of one or two hundred feet in cañon-bluffs of Elkhorn Creek, in the base of which a thin bed of rotten lignite was found. He failed to detect any traces of organic remains in these beds, and am, in consequence, unable to refer them to their place in geological time, though I believe they belong to the Tertiary. The northerly inclination of these beds at a gentle angle continues across the low upland to the Buffalo Fork, and in the hills which rise on the north of this stream similar beds of clays and buff sandstone outcrop, where they attain elevation of above 2,000 feet above the valley. These hills are capped by bed of partially cemented bowlders and pebbles, the degradation of which has strewn the slopes with drift *débris*. The above-mentioned Tertiary deposits were met in the gradually-ascending upland to the east as high up as the debouchure of the Buffalo Fork, though they were not observed to extend up on the mountain sides in this quarter.

From the Buffalo Fork the route led up Black Rock Creek, through the To-owo-tu Pass, across the continental divide into the Wind River Valley. Just within the western entrance to the pass, on the north side, a group of high mountains occupies the interval between Black Rock Creek and Buffalo Fork, of which Buffalo Fork Peak forms the culmination. The bases of these mountains, together with the corresponding heights on the opposite side of Buffalo Fork, and which together

form the gateway to the upper mountain valley of this stream, are composed of Archæan (gneissose) rocks, which constitute a thousand or more feet of the lower portion of the cañon-walls. Upon these rests a thickness of one hundred feet or more of quartzite, and upon the latter a heavy ledge of the lower Quebec limestone occurs, forming the summit of Buffalo Fork Peak. This mountain is connected with the lower peak, station 49, to the southwest, by a long spur, in which this limestone forms the coping and dips in the same direction. It is overlaid by the thin-bedded upper ledge, with a considerable thickness of intervening clays and indurated fine-grit layers, in all of which Trilobites and other Silurian fossils were found. These beds are in turn overlaid, without apparent unconformability, by several hundred feet of Carboniferous, which latter crowns the summit of station 49. The southern slopes of these mountains steeply descend over heavy ledges of limestone and grayish buff and reddish hard sandstone into the valley of Black Rock Creek, where the deep red sandy shales and sandstone of the Triassic outcrop, and the presence of which in the adjacent slopes is plainly hinted by the rank herbaceous vegetation its soil supports. The same deposits are also seen to the east or southeast, reclining on the southeasterly declivities of these mountains, in the gap which separates them from the volcanic escarpments of the main water-shed. This group of mountains appears to owe its origin to a local bulging of the crest, since to the north the sedimentaries which it bears on its crest are seen to dip off in that direction, as they do in the opposite direction on their western and southern flanks, overlooking the lower valley of the Buffalo Fork and the upper course of Black Rock Creek in the approach to To-owo-tu Pass. The latter valley, like the Teton Pass, (and for that matter, so many of the passes in the mountains of this region,) is excavated in the Triassic red-beds. To the southwest of the Black Rock indications of the presence of the Jurassic are obscurely revealed here and there, but soon concealed in the long, wooded slopes, which are continuous with the Tertiary ridges of the Mount Leidy region.

In the valley of Black Rock Creek are encountered heavy masses of volcanics consisting largely of a sort of conglomerate breccia. These continue to the summit of To-owo-tu Pass, where they are seen in intimate association with some of the most remarkable volcanic accumulations. The latter rise into lofty horizontally-bedded mountains whose sides are sculptured in colossal architectural forms, and which form a grand portal to the pass across the continental divide. The heights command Jackson's Valley and the Teton to the westward, while to the eastward lies the low country of the Wind River Valley, diversified by the peculiar variegated formations which occupy a great basin bounded on the north by the continuation of the volcanic cliffs. These latter offer on close examination the most varied appearance, being made up of volcanic ash, sands, breccias, and conglomerate, which are partly of aqueous origin, as shown by their bedded condition. These strata are practically horizontal, although they incline slightly in various directions, but appear not to have been affected by disturbances such as elevated the Buffalo Fork Mountains, and hence the more recent date of their formation is inferred.

To the east, north, and northwest, these deposits are spread over an immense area of elevated mountain country, themselves constituting some of the highest elevations in the region. Their *débris* effectually conceals the older rocks in the To-owo-tu Pass, to the south of which the same great escarpments are continued for a short distance, when they give way to lower levels of long, wooded mountain summits. In

the latter appear heavy exposures of dark, compact, and scoriaceous lavas, with trachytic domes. These extend along the summit of the water-shed several miles in a southerly direction, and may reach to the near vicinity of Union Pass.

Descending into the Wind River Valley, a few miles below the summit of the pass, the bluff banks along the stream show a hundred feet or so of cream-colored and buff sandstone and gritty clays. These deposits gradually increase in vertical exposure as we descend the valley, the beds gently inclining in the same direction, or southeasterly. At a point where the stream opens out into the intervale-bordered valley these beds are seen to be overlaid by a series of variegated, red, greenish, and buff or ash colored clays, and indurated arenaceous beds, which make up a thickness of several hundred feet in a rather high plateau or terrace outlying the high volcanic ridges which hem the basin on the north. These deposits continue down the valley several miles farther, lower beds coming to view as we descend. Above De Noir Creek, in a low bluff on the north side of Wind River, a thin seam of lignite occurs in connection with bluish-drab and chocolate-colored clays and rusty, soft sandstone. In the neighborhood of Warm Water Creek we first met the older sedimentaries, which appear in a mass of reddish and light colored sandstones reclining on the foot of the Wind River Mountains, dipping 20° to 30° northeasterly. The sandstones are underlaid by older formations, which rise successively higher and higher upon the northeastern face of the range.

In the same neighborhood, on the northeast side of the river, a series of beautifully exposed deposits, consisting of variegated, light-red, and drab clays, and bands of ferruginous sandstone, capped by yellowish sandstone, appear, and which seem to underlie conformably the beforementioned horizontal deposits. These variegated beds continue thence far down the valley; but above Crow Heart Butte they are crowded inland, the terraces which bound the stream showing buff sandstones, and which, together with brownish clays, make up the rock exposed in the above-named butte. In the vicinity of the confluence of North Fork the variegated beds exhibit their greatest development, as shown at any one point observed. Here they are seen to rest upon brown clays, recalling the clays interbedded with the sandstones in Crow Heart Butte, and all of which rest unconformably upon the more steeply-inclined Jurassic limestone and Triassic sandstone, which here form a wide belt of exposures in the foot of the mountain. The variegated beds are also slightly inclined northeasterly.

Below Bull Creek we soon enter a region where the Mesozoics extend several miles out into the plains, which here intervene between the river and the foot of the mountains; a section where they exhibit much displacement, which contrasts with the grand simplicity which uniformly characterizes the position of the Mesozoic and Paleozoic formations in the great foreland slopes of the range between the Warm Water and Little Wind Rivers.

Thence, on their return, the party passed through Mr. Chittenden's district, which was visited by Dr. Endlich.

The necessity of a careful examination of the various geological formations in the field, and a review by a practical paleontologist of the various districts that have from year to year been surveyed by the different geologists of this and other surveys, has been long felt. Such a work, indeed, was imperatively necessary before a consistent and comprehensive classification of the formations could be established. This

duty was assigned to Dr. C. A. White, the palæontologist of this Survey, and he took the field at the beginning of the past season and continued his labors until its close. The special duty with which he was charged was to pursue such lines of travel as would enable him to make critical examination of the geological formations in succession as they are exposed to view on both sides of the Rocky Mountain chain, and also on both sides of the Uintah chain; to collect and study the fossils of these formations in such detail as to settle, as far as possible, the questions of the natural and proper vertical limits of the formations, their geographical range, their correlation with each other, and to define the paleontological characteristics of each.

He has pursued his researches with such success during the past season as to demonstrate the necessity of continuing this class of investigations by various lines of travel across what is generally known as the great Rocky Mountain region, especially those portions of it that have been surveyed, as well as those in which surveys are in progress.

Among other important results, he has shown the identity of the lignitic series of strata east of the Rocky Mountains in Colorado with the Fort Union group of the Upper Missouri River, and also its identity with the great Laramie group of the Green River Basin and other portions of the region west of the Rocky Mountains. He also finds the planes of demarkation between any of the Mesozoic and Cenozoic groups, from the Dakota to the Bridger inclusive, to be either very obscure or indefinable; showing that whatever catastrophal or secular changes took place elsewhere during all that time, sedimentation was probably continuous in what is now that part of the continent from the earliest to the latest of the epochs just named. Other results and further details of the season's work will appear in the following paragraphs.

The general course of travel pursued by Dr. White during the season was as follows, not including the numerous detours, meanderings, and side trips which the work necessitated: Outfitting at Cheyenne, he journeyed southward, traversing in various directions a portion of the great plains which lie immediately adjacent to the eastern base of the Rocky Mountains in Colorado. The most easterly point thus reached was some sixty miles east of the base of the mountains and the most southerly point about twenty-five miles south of Denver. Returning to Denver to renew his outfit, he crossed the Rocky Mountains by way of Boulder Pass, through Middle Park. After making certain comparative examinations of the Mesozoic and Cenozoic formations in Middle Park he proceeded westward to the headwaters of the Yampa River, following that stream down to the western foot-hills of the Park Range of mountains.

Here resuming his comparative examinations of the Mesozoic and Cenozoic strata, he passed down the valley of the Yampa as far as Yampa Mountain, one of those peculiar and remarkable up-thrusts of Paleozoic rocks through Mesozoic strata. In all this area, as well as that between the Yampa and White Rivers, the Laramie group reaches a very great and characteristic development, and it received careful investigation, yielding some of the most important results of the season's work. Crossing the ground between the two rivers named to White River Indian agency, thence down White River Valley about one hundred miles; thence to Green River, crossing it at the southern base of the Uintah Mountains, making many detours on the way, he reviewed the geology of the region which he had surveyed during the previous season. This review brought out not only the important paleontological facts before referred to, but it also added materially to the elucidation of the geological

structure of the region which lies between the eastern end of the Uintah Mountain Range on the west and the Park Range on the east.

Beyond Green River he pursued his travels westward, studying the Mesozoic and Cenozoic strata that flank the Uintah Range upon its south side, and making comparisons of both their lithological and paleontological characteristics.

In this way he traversed the whole length of the Uintah Range, crossing at its junction with the Wasatch Range over into the valley of Great Salt Lake. Recrossing the Wasatch to the north side of the Uintah Range he continued his examinations of the Cretaceous and Tertiary strata into and entirely across the great Green River Basin, leaving the field at the close of the season at Rawlins Station, on the Union Pacific Railroad.

A general statement of the results of the season's work has been given in a previous paragraph, but the following additional summary will make the statement somewhat clearer, being made after the route of the season's travel has been indicated. The formations of later Mesozoic and earlier Cenozoic ages, especially those to which Dr. White, in former publications, has applied the provisional designation of "Post-Cretaceous," have received particular attention. The extensive explorations of Dr. Hayden in former years, and the paleontological investigations of the late Mr. Meek, pointed strongly to the equivalency of the Fort Union beds of the Upper Missouri River with the lignitic formation as it exists along the base of the Rocky Mountains in Colorado, and also to the equivalency of the latter with the Bitter Creek series west of the Rocky Mountains. The investigations of this year have fully confirmed these views by the discovery not merely of one or two doubtful species common to the strata of each of these regions, but by an identical molluscan fauna ranging through the whole series in each of the regions named.

This shows that the strata just referred to all belong to one well-marked period of geological time, to the strata of which Mr. King has applied the name of "Laramie group," (Point of Rocks group of Powell.) His investigations also show that the strata, which in former reports by himself and Professor Powell have been referred to the base of the Wasatch group, also belong to the Laramie group, and not to the Wasatch. He has reached this later conclusion not merely because there is a similarity of type in the fossils obtained from the various strata of the Laramie group with those that were before in question, but by the specific identity of many fossils that range from the base of the Laramie group up into and through the strata that were formerly referred to the base of the Wasatch. Furthermore, some of these species are found in the Laramie strata on both sides of the Rocky Mountains. Thus the vertical range of some of these species is no less than three thousand feet, and their present known geographical range more than a thousand miles.

Besides the recognition of the unity of the widely-distributed members of the formation of this great geological period, bounded by those of undoubted Cretaceous age below and those of equally undoubted Tertiary age above, his further observations have left comparatively little doubt that the "Lake Beds" of Dr. Hayden, as seen in Middle Park, the "Brown's Park group" of Professor Powell, and the "Uintah group" of Mr. King, all belong to one and the same epoch, later than and distinctly separte from the Bridger group.

In that portion of the region which lies adjacent to the southern base of the Uintah Mountain Range, and which is traversed by Lake Fork

and the Du Chesne River, not only the Uintah group, but both the Green River and Bridger groups also, are well developed, each possessing all its peculiar and usual characteristics as seen at the typical localities in the great Green River Basin, north of the Unitah Mountains. This, added to the known existence of Bridger strata in White River Valley, and the extensive area occupied by the Green River group between White and Grand Rivers, has added very largely to our knowledge of the southward extension of those formations.

In all the comparative examinations of the formations or groups of strata that have just been indicated, he has paid especial attention to their boundaries,or planes of demarkation, crossig and recrossing them wherever opportunity offered, noting carefully every change of both lithological and paleontological characters. While he has been able to recognize with satisfactory clearness the three principal groups of Cretaceous strata, namely, the Dakota, Colorado, and Fox Hills, on both sides of the Rocky and Uintah Mountains, respectively, they evidently constitute an unbroken series, so far as their origin by continuous sedimentation is concerned. While each of the groups possesses its own peculiar paleontological characteristics, it is also true that certain species pass beyond the recognized boundaries of each within the series.

The stratigraphical plane of demarkation between the Fox Hills, the uppermost of the undoubted Cretaceous groups, and the Laramie group, the so-called Post-Cretaceous, is equally obscure; but the two groups are paleontologically very distinct, inasmuch as the former is of marine origin, while the latter, so far as is now known, contains only brackish-water and fresh-water invertebrate forms. He reports a similar obscurity, or absence of a stratigraphical plane of demarkation, between the Laramie and Wasatch groups, although it is there that the final change from brackish to entirely fresh water took place over that great region. Furthermore, he finds that while the three principal groups of the fresh-water Tertiary series west of the Rocky Mountains, namely, the Wasatch, Green River, and Bridger groups, have each peculiar characteristics, and are recognizable with satisfactory distinctness as general divisions, they really constitute a continuous series of strata, not separated by sharply-defined planes of demarkation, either stratigraphical or paleontological.

During the progress of the field-work, as above indicated, large and very valuable collections of fossils have been made, all of which will constitute standards of reference in the future progress of the work, and quite a large number of the species are new to science. These are now being investigated, and will be published in the usual paleontological reports of the survey.

Messrs. S. H. Scudder, of Cambridge, and F. C. Bowditch, of Boston, spent two months in Colorado, Wyoming, and Utah, in explorations for fossil insects, and in collecting recent Coleoptera and Orthoptera, especially in the higher regions. They made large collections of recent insects at different points along the railways from Pueblo to Cheyenne and from Cheyenne to Salt Lake, as well as at Lakin, Kans., Garland, and Georgetown, Colo., and in various parts of the South Park and surrounding region.

For want of time, they were obliged to forego an anticipated trip to White River, to explore the beds of fossil insects known to exist there. Ten days were spent at Green River and vicinity in examining the Tertiary strata for fossil insects, with but poor results; the Tertiary beds of the South Park yielded but a single determinable insect, but near Flo-

rissant the Tertiary basin, described by Mr. Peale in one of the annual reports of the survey, was found to be exceedingly rich in insects and plants.

In company with Rev. Mr. Lakes, of Golden, Mr. Scudder spent several days in a careful survey of this basin and estimates the insect-bearing shales to have an extent at least fifty times as great as those of the famous locality at Œningen in Southern Bavaria. From six to seven thousand insects and two or three thousand plants have already been received from Florissant, and as many more will be received before the close of the year.

Mr. Scudder was also able to make arrangements in person with parties who have found a new and very interesting locality of Tertiary strata in Wyoming, to send him all the specimens they work out, and he confidently anticipates receiving several thousand insects from them in the course of the coming winter. The specimens from this locality are remarkable for their beauty. There is, therefore, every reason to believe the Tertiary strata of the Rocky Mountain region are richer in remains of fossil insects than any other country in the world, and that within a few months the material at hand for the elaboration of the work on fossil insects, which Mr. Scudder has in preparation for the survey, will be much larger than was ever before subject to the investigation of a single naturalist.

Prof. Joseph Leidy, the eminent comparative anatomist and microscopist, made his second visit to the West the past season, under the auspices of the survey. He made a careful exploration of the country about Fort Bridger, Uintah Mountains, and the Salt Lake Basin, in search of rhizopods. He has been engaged for a long time on a memoir on this subject, which will eventually form one of the series of the quarto Reports of the Survey.

The rhizopods are the lowest and simplest forms of animals, mostly minute, and requiring high power of the microscope to distinguish their structure. While most of them construct shells of great beauty and variety, their soft part consists of a jelly-like substance. This the animal has the power of extending in threads or finger-like processes, which are used as organs of commotion and prehension, often branching. From the appearance of their temporary organs, resembling roots, the class of animals has received its name of rhizopoda, meaning literally root-footed.

In compensation for the smallness of these creatures, they make up in numbers, and it is questionable whether any other class of animals exceed them in importance in the economy of nature. Geological evidence shows that they were the starting-point of animal life in time, and their agency in rock-making has not been exceeded by later higher and more visible forms.

With the marine kind, known as foraminifera, we have been longest familiar. The beautiful many-chambered shells of these—for the most part just visible to the naked eye—form a large portion of the ocean-mud and the sands of the ocean-shore. Shells of foraminifera likewise form the basis of miles of strata of limestone, such as the chalk of England and the limestones of which Paris and the pyramids of Egypt are built.

Fresh-water rhizopods, though not so abundant as marine forms, are nevertheless very numerous. They mainly inhabit our lakes, ponds, and standing waters, but they also swarm in sphagnous swamps, and ever live in newest earth. Professor Leidy has devoted several years of study to the fresh-water rhizopods of the eastern portion of our country, and his especial object in the past expedition was to investigate those which are to be found in the elevated regions of the Rocky Mountains.

The botany of the Survey was represented the past season by the two great masters of that department, Sir Joseph D. Hooker, director of the Gardens of Kew, England, and president of the Royal Society of London; and Prof. Asa Gray, of Cambridge, Mass. Their examinations extended over a great portion of Colorado, Wyoming, Utah, Nevada, and California. Their investigation into the alpine floras and tree vegetation of the Rocky Mountains and Sierra Nevada enabled them to give a clear idea of the relations and influence of the climatic conditions on both sides of the great mountain-ranges.

Sir Joseph Hooker, whose botanical researches embrace the greater part of Europe; the Indies, from the bay of Bengal across the Himalaya's to Thibet; the Antarctic regions and the southern part of South America, New Zealand, Australia, South Africa, Morocco and Asia Minor, presents in the English periodical "Nature" for October 25 an outline of his studies during the season, and this outline when filled out will form a most important report for the eleventh annual Report of the Survey. It will be seen at a glance that the report will be of the most comprehensive character, and cannot fail to be of the highest interest to our people. The tree vegetation, and especially the coniferæ, were made special objects of study, and many obscure points were cleared up.

Of a section of the Rocky Mountains comprising Colorado, Wyoming, and Utah, Dr. Hooker says:

Such a section of the Rocky Mountains must hence contain representatives of three very distinct American floras, each characteristic of immense areas of the continent. There are two temperate and two cold or mountain floras, viz: (1) a prairie flora derived from the eastward; (2) a so-called desert and saline flora derived from the west; (3) a subalpine; and (4) an alpine flora; the two latter of widely different origin, and in one sense proper to the Rocky Mountain ranges.

The principal American regions with which the comparison will have first to be instituted are four. Two of these are in a broad sense humid; one, that of the Atlantic coast, and which extends thence west to the Mississippi River, including the forested shores of that river's western affluents; the other, that of the Pacific side, from the Sierra Nevada to the western ocean; and two inland, that of the northern part of the continent extending to the Polar regions, and that of the southern part extending through New Mexico to the Cordillera of Mexico proper.

The first and second (Atlantic plus Mississippi and the Pacific) regions are traversed by meridional chains of mountains approximately parallel to the Rocky Mountains, namely, on the Atlantic side by the various systems often included under the general term appalachian, which extend from Maine to Georgia, and on the Pacific side by the Sierra Nevada, which bound California on the east. The third and fourth of the regions present a continuation of the Rocky Mountains of Colorado and Utah, flanked for a certain distance by an eastern prairie flora extending from the British Possessions to Texas, and a western desert or saline flora, extending from the Snake River to Arizona and Mexico. Thus the Colorado and Utah floras might be expected to contain representatives of all the various vegetations of North America, except the small tropical region of Florida, which is confined to the extreme southeast of the continent.

The most singular botanical feature of North America is unquestionably the marked contrast between its two humid floras, namely, those of the Atlantic plus Mississippi, and the Pacific one; this has been ably illustrated and discussed by Dr. Gray in various communications to the American Academy of Sciences, and elsewhere, and he has further largely traced the peculiarities of each to their source, thus laying the foundations for all future researches into the botanical geography of North America; but the relations of the dry intermediate region either to these or to the floras of other countries had not been similarly treated, and this we hope that we have now materials for discussing.

Dr. Hooker sums up the results of the joint investigations of Dr. Gray and himself, aided by Dr. Gray's previously intimate knowledge of the elements of the American flora, from the Mississippi to the Pacific coast:

That the vegetation of the middle latitudes of the continent resolves itself into three principal meridional floras, incomparably more diverse than those presented by any similar meridians in the Old World, being, in fact, as far as the trees, shrubs, and many genera of herbaceous plants are concerned, absolutely distinct. These are the two humid and the dry intermediate regions above indicated.

Each of these, again, is subdivisible into three, as follows:

1. The Atlantic slope plus Mississippi region, subdivisible into (α) an Atlantic, (β) a Mississippi Valley, and (γ) an interposed mountain region with a temperate and subalpine flora.

2. The Pacific slope, subdivisible into (α) a very humid, cool, forest-clad coast range; (β) the great, hot, drier Californian valley formed by the San Juan River flowing to the north and the Sacramento River flowing to the south, both into the Bay of San Francisco; and (γ) the Sierra Nevada flora, temperate, subalpine, and alpine.

3. The Rocky Mountain region, (in its wildest sense extending from the Mississippi beyond its forest region to the Sierra Nevada,) subdivisible into (α) a prairie flora, (β) a desert or saline flora, (γ) a Rocky Mountain proper flora, temperate, subalpine, and alpine.

As above stated, the difference between the floras of the first and second of these regions is specifically, and to a great extent generically, absolute; not a pine or oak, maple, elm, plane or birch of Eastern America extends to Western, and genera of thirty to fifty species are confined to each. The Rocky Mountain region again, though abundantly distinct from both, has a few elements of the eastern region and still more of the western.

Many interesting facts connected with the origin and distribution of American plants, and the introduction of various types into the three regions, presented themselves to our observation or our minds during our wanderings. Many of these are suggestive of comparative study with the admirable results of Heer's and Lesquereux's investigations into the Pliocene and Miocene plants of the north temperate and frigid zones, and which had already engaged Dr. Gray's attention, as may be found in his various publications. No less interesting are the traces of the influence of a glacial and a warmer period in directing the course of migration of Arctic forms southward, and Mexican forms northward in the continent, and of the effects of the great body of water that occupied the whole saline region during (as it would appear) a glacial period.

Lastly, curious information was obtained respecting the ages of not only the big trees of California, but of equally aged pines and junipers, which are proofs of that duration of existing conditions of climate for which evidence has hitherto been sought rather among fossil than among living organisms.

Up to the year 1874 rumor had been telling many marvelous stories of strange and interesting habitations of a forgotten people, who once occupied the country about the headwaters of the Rio San Juan, but these narrations were so interwoven with romance that but few people placed much reliance upon them. To those well versed in archæology, ruins of an extensive and interesting character were known to exist throughout New Mexico and Arizona, and the various reports of Abert, Johnson, Sitgreaves, Simpson, Whipple, Newberry, and others form our most interesting chapter in ancient American history; but their researches, aside from the meager accounts published by Newberry, throw no light on the marvelous cliff dwellings and towns north of the San Juan. In 1874 the photographic division of the United States Geological Survey was instructed, in connection with its regular work, to visit and report upon these ruins, and in pursuance of this object made a hasty tour of the region about the Mesa Verde and the Sierra el Late, in Southwestern Colorado, the results of which trip, as expressed by Bancroft, in the Native Races of the Pacific Coast, "although made known to the world only through a three or four days' exploration by a party of three men, are of the greatest importance." A report was made and published, with fourteen illustrations, in the Bulletin of the United States Geological and Geographical Survey of the Territories, second series, No. 1.

The following year the same region was visited by Mr. W. H Holmes, one of the geologists of the Survey, and a careful investigation made of all the ruins. Mr. Jackson, who had made the report the previous year, also revisited this locality, but extended his explorations down the San Juan to the mouth of the De Chelly, and thence to the Moqui villages in Northeastern Arizona. Returning, the country between the Sierra Abajo and La Sal and the La Plata was traversed, and an immense num-

ber of very interesting ruins were first brought to the attention of the outside world by the report which was published the following winter by Messrs. Holmes and Jackson, in the Bulletin of the Survey, Vol. II, No. 1.

The occasion of the centennial exhibition at Philadelphia led to the idea of preparing models of these ruins for the clearer illustration of their peculiarities, four of which were completed in season for the opening of the exhibition. Since that time not only the number of these interesting models has been increased, but they have been perfected in execution and faithful delineation of these mysterious remains of an extinct race who once lived within the borders of our western domain.

A visit to the rooms of Mr. Jackson, photographer of the Survey, enables one to inspect in miniature size the dwellings of the Moqui, and in full size a large collection of the ceramics and implements of those ancient and extinct people of our continent. A study of the models will give a very excellent idea of the ruined dwellings themselves. The first of these models, executed by Mr. Holmes, with whom the idea originated, represents the cliff house of the Mancos Cañon, the exterior dimensions of which are 28 inches in breadth by 46 inches in height, and on a scale of 1.24, or two feet to the inch. This is a two-story building, constructed of stone, occupying a narrow ledge in the vertical face of the bluff 700 feet above the valley, and 200 feet from the top. It is 24 feet in length and 14 feet in depth, and divided into four rooms on the ground-floor. The beams supporting the second floor are all destroyed. The doorways, serving also as windows, were quite small, only one small aperture in the outer wall facing the valley. The exposed walls were lightly plastered over with clay, and so closely resembled the general surface of the bluff that it becomes exceedingly difficult to distinguish them at a little distance from their surroundings.

The second model of this series was constructed by Mr. Jackson, and represents the large "cave town," in the valley of the Rio de Chelly near its junction with the San Juan. This town is located upon a narrow bench, occurring about 80 feet above the base of a perpendicular bluff some 300 feet in height. It is 545 feet in length, about 40 feet at its greatest depth, and shows about 75 apartments on its ground-plan. The left-hand third of the town, as we face it, is overhung some distance by the bluff, protecting the buildings beneath much more perfectly than the others. This is the portion represented by the model. A three-story tower forms the central feature; upon either side are rows of lesser buildings, built one above another upon the sloping floor of rock. Nearly all these buildings are in a fair state of preservation. This model is 37 by 47 inches, outside measurements, and the scale 1.72, or 6 feet to the inch. A "restoration" of the above forms the third in the series, of the same size and scale, and is intended, as its name implies, to represent as nearly as possible the original condition of the ruin. In this we see that the approaches were made by ladders and steps hewn in the rock, and that the roofs of one tier of rooms served as a terrace for those back of them, showing a similarity, at least, in their construction to the works of the Pueblos in New Mexico and Arizona. Scattered about over the buildings are miniature representations of the people at their various occupations, with pottery and other domestic utensils.

The "triple-walled tower," at the head of the McElmo, is the subject of the fourth model. It was constructed by Mr. Holmes, and represents, as indicated by its title, a triple-walled tower, situated in the midst of a considerable extent of lesser ruins, probably of dwellings, occupying

a low bench bordering the dry wash of the McElmo. The tower is 42 feet in diameter, the wall 2 feet thick, and now standing some 12 feet high. The two outer walls inclose a space of about 6 feet in width, which is divided into 14 equally-sized rooms, communicating with one another by small window-like doorways. The next is a "cliff-house" in the valley of the Rio de Chelly. It is about 20 miles above the cave town already spoken of. This is a two-story house, about 20 feet square, occupying a ledge some 75 feet above the valley, and overhung by the bluff. The approach from the valley is by a series of steps hewn in the steep face of the rock; and this method was the one most used by the occupants, although there is a way out to the top of the bluff. This model is 42 inches in height by 24 broad, and is built upon a scale of 1.36.

Téwa, one of the seven Moqui towns in Northeastern Arizona, is a very interesting and instructive model, representing, as it does, one of the most ancient and best authenticated of the dwellings of a people who are supposed to be the descendants of the cliff-dwellers. Téwa is the first of the seven villages forming the province as we approach them from the east, and occupies the summit of a narrow mesa some 600 feet in height and 1,200 yards in length, upon which are also two other somewhat similar villages. The approach is by a circuitous roadway hewn in the perpendicular face of the bluff, which surrounds the mesa upon all sides. It is the only approach accessible for animals to the three villages. Other ladder-like stairways are cut in the rock, which are used principally by the water carriers, for all their springs and reservoirs are at the bottom of the mesa. This village is represented upon a scale of 1 inch to 8 feet, or 1.96. The dimensions of the model are 36 inches in length, 29 inches in width, and 14 inches in height.

In the spring of 1877, Mr. Jackson made a tour over much of the northern part of New Mexico, and westward to the Moqui towns in Arizona, and secured materials for a number of very interesting models, illustrating the methods of the Pueblos or town-builders in the construction of their dwellings. Two villages have been selected for immediate construction, as showing the most ancient and best known examples of their peculiar architecture, viz, Taos and Acoma; the one of many-storied, terraced houses, and the other built high up on an impregnable rock. The model of Taos is now completed, the dimensions of which are 42 by 39 inches, and the scale one inch to twenty feet, 1:240.

Of this town Davis says:

> It is the best sample of the ancient mode of building. Here are two large houses three or four hundred feet in length, and about one hundred and fifty feet wide at the base. They are situated upon opposite sides of a small creek, and in ancient times are said to have been connected with a bridge. They are five and six stories high, each story receding from the one below it, and thus forming a structure terraced from top to bottom. Each story is divided into numerous little compartments, the outer tier of rooms being lighted by small windows in the sides, while those in the interior of the building are dark, and are principally used as storerooms. * * * The only means of entrance is through a trap-door in the roof, and you ascend from story to story by means of ladders on the outside, which are drawn up at night.

Their contact with Europeans has modified somewhat their ancient style of buildings, principally in substituting doorways in the walls of their houses for those in the roof. Their modern buildings are rarely over two stories in height, and are not distinguishable from those of their Mexican neighbors. The village is surrounded by an adobe wall, which is first included within the limits of the model, and incloses an area of eleven or twelve acres in extent. Within this limit are four of their *estufas*, or secret council-houses. These are circular underground

apartments, with a narrow opening in the roof, surrounded by a palisade, ladders being used to go in and out.

These models are first carefully built up in clay, in which material all the detail is readily secured, and are then cast in plaster, a mold being secured by which they are readily multiplied to any extent. They are then put in the hands of the artists and carefully colored in solid oil paints to accurately resemble their appearance in nature, and, in the case of restorations or modern buildings, all the little additions are made which will give them the appearance of occupation. The survey is in possession of the data for the construction of many more models, and they will be brought out as opportunity is given. They have also, in connection with the views, multiplied many of the curious pieces of pottery which have been brought back from that region by the various parties connected with the survey.

During the season of 1877 it was found impracticable to place a separate party in the field for zoölogical work, as Dr. Elliott Coues, the naturalist of the Survey, was fully occupied during the summer at the Washington office in the care of the numerous publications of the Survey which have appeared during the present year.

Very respectfully, your obedient servant,

F. V. HAYDEN,
United States Geologist.

Hon. CARL SCHURZ,
Secretary of the Interior, Washington, D. C.